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(54) Pipe plugs

(57) A pipe plug (10) for sealing a pipe (12) at a selected location has a circumferential array of slips (18). In a first stage of securing the plug (10) in position, the slips (18) are moved relative to ramped faces (22) to engage against the interior of the pipe (12). In a second stage, the slips (18) are locked in that position by upstream pipeline pressure acting on a piston (30) to cause radial extension of plungers (26) via over-centre toggle links (40).

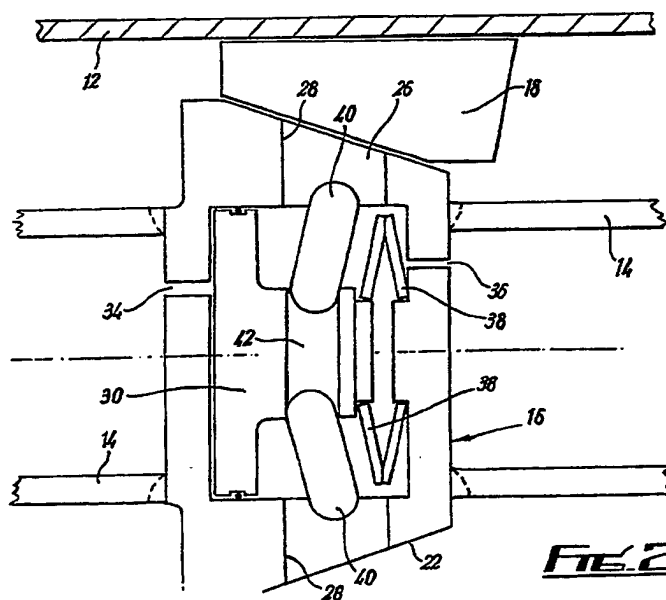
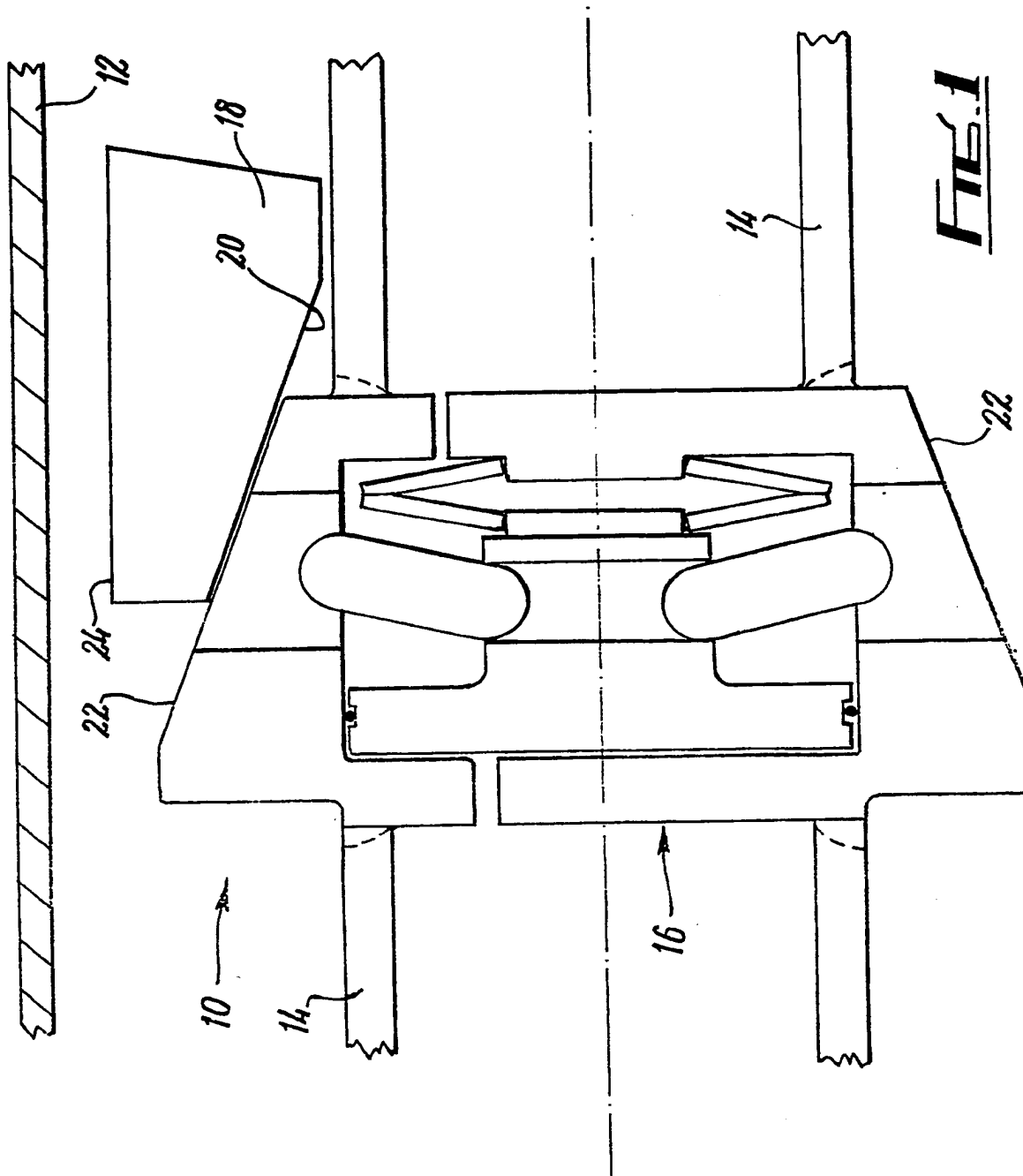
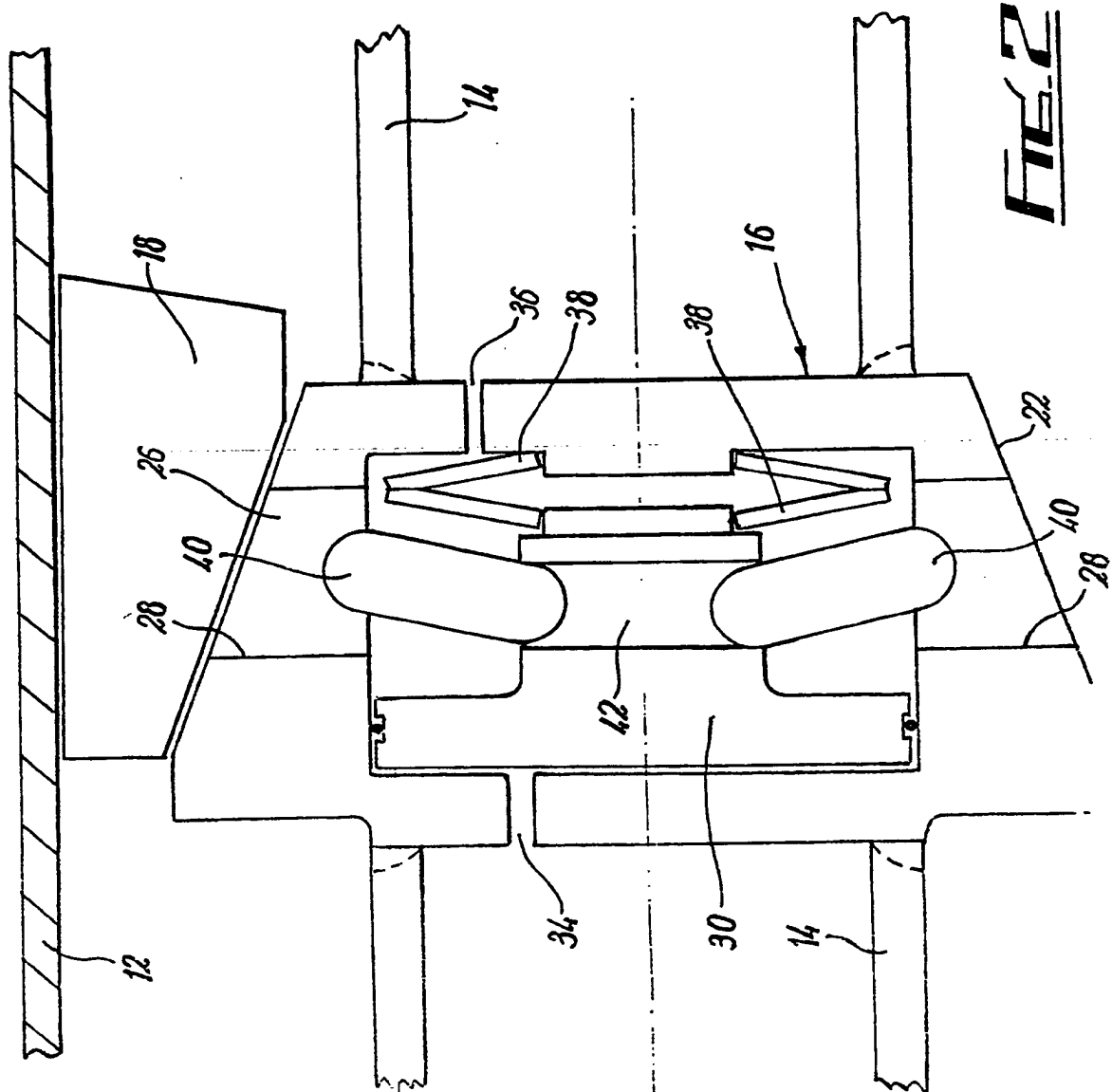


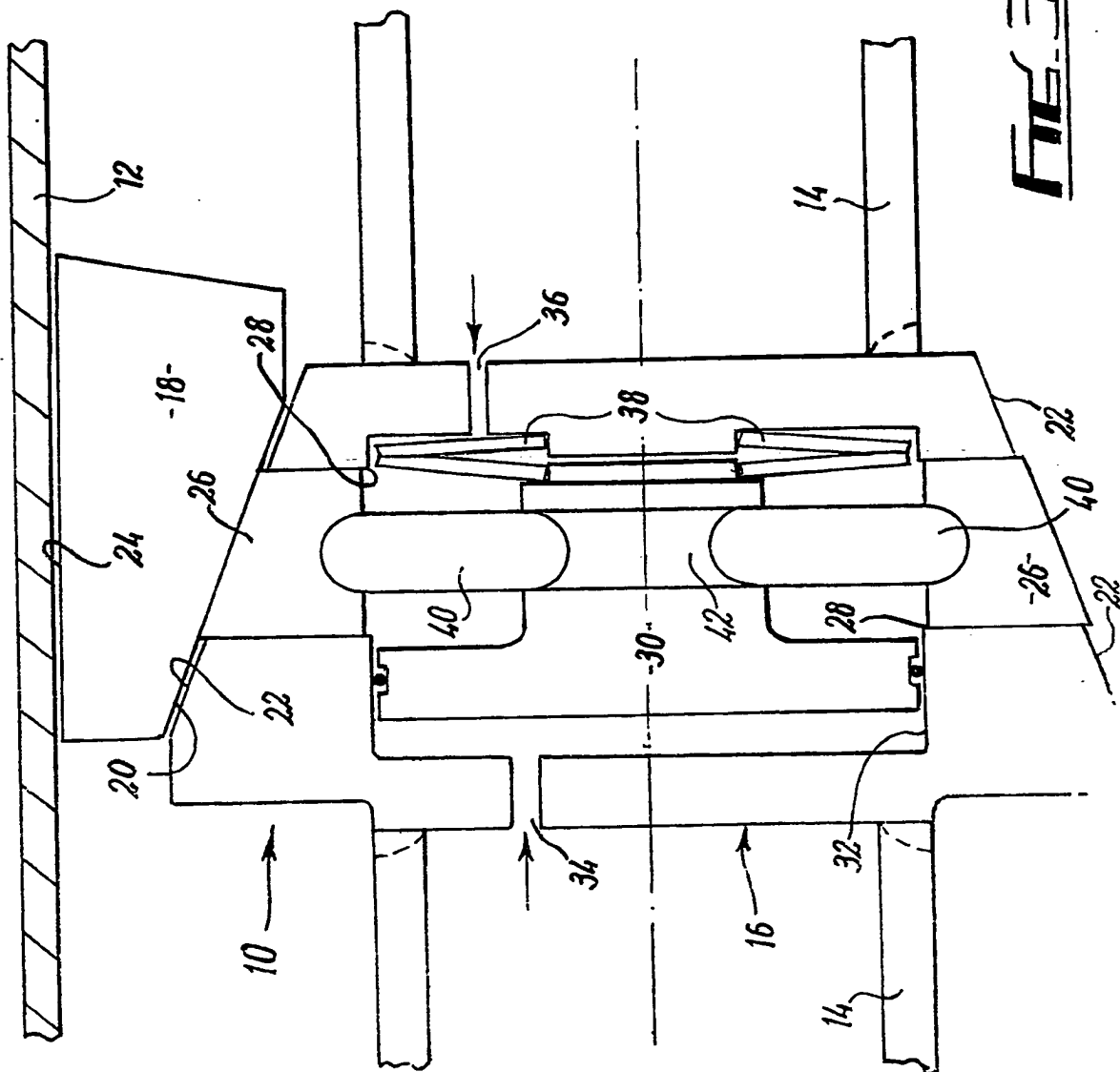
FIG. 2





FILE

FIG. 3



1 "PIPE PLUGS"

2
3 This invention relates to pipe plugs, and relates more
4 particularly to pigs for temporarily plugging pipelines
5 at selected locations.

6
7 It is well-known to employ pipelines to carry oil, gas
8 or mixtures of these for substantial distances across
9 land or sea. It may become necessary or desirable
10 temporarily to block a pipeline at a location not
11 fitted with a shut-off valve. In particular, if it is
12 required to work on a short length of a long pipeline
13 (eg to repair a leak or to fit a branch) at a location
14 remote from either end of the pipeline, the choices are
15 usually either to drain the entire pipeline or to
16 isolate that short length such that only that short
17 length requires to be drained. The latter course of
18 action is preferable if the short length can be
19 reliably isolated.

20
21 According to a first aspect of the present invention
22 there is provided a pipe plug comprising a pig adapted
23 to be transported along the bore of a pipeline and to
24 be controllably anchored at a selected location along

1 said pipeline, said pig comprising anchor means
2 engageable with the bore of the pipeline at said
3 selected location in an initial stage of anchor
4 operation, and locking means for locking the anchor
5 means in engagement with the bore of the pipeline at
6 said selected location in a subsequent stage of anchor
7 operation.

8
9 The locking means preferably comprises over-centre
10 toggle means disposed to act upon said anchor means
11 after said initial stage of anchor operation to lock
12 said anchor means in engagement with the pipeline bore
13 by over-centring action whereby said anchor means are
14 subsequently retained in a locked condition in
15 engagement with the bore of the pipeline at least until
16 a subsequent reversal of said over-centring action of
17 said toggle means. Means to induce said over-centring
18 action of said toggle means may comprise pressure
19 sensitive means responsive to a difference in pressures
20 at opposite ends of said pig. Said pressure sensitive
21 means preferably comprises a piston means actuatable by
22 differential pressure across said piston means.

23
24 Said locking means may incorporate spring means
25 biasing said over-centre toggle means away from a
26 configuration in which said over-centring action
27 occurs.

28
29 Said anchor means preferably comprises slip means and
30 wedge means movable relative to said slip means to urge
31 said slip means into engagement with the bore of said
32 pipeline at said selected location as said initial
33 stage of anchor operation.

34
35 Said slip means preferably comprises a plurality of

1 slips disposed around the periphery of the pig and
2 arranged to be movable radially outwards of said pig by
3 relative movement of said wedge means in a longitudinal
4 direction. Said wedge means preferably comprises a
5 like plurality of wedges longitudinally movable along
6 respective paths radially inwards of an associated slip
7 and radially outwards of said over-centre toggle means.
8 Means to cause conjoint longitudinal movement of said
9 wedges may comprise hydraulic piston means which
10 preferably comprises a hydraulic piston longitudinally
11 movable to act simultaneously on each said wedge.

12
13 Said pig preferably further comprises seal means for
14 sealing said pig to the bore of said pipeline whereby
15 substantially to prevent interchange of fluid between
16 portions of said pipeline on either side of said pig.

17
18 According to a second aspect of the present invention
19 there is provided a method of anchoring a pipe-plugging
20 pig at a selected location along a pipeline, said
21 method comprising the steps of providing a
22 pipe-plugging pig according to the first aspect of the
23 present invention, transporting said pig along the bore
24 of the pipeline to said selected location, causing the
25 anchor means of said pig to undergo an initial stage of
26 anchor operation to engage the bore of the pipeline at
27 said selected location, and subsequently mechanically
28 locking said anchor means in engagement with the bore
29 of the pipeline at said selected location.

30
31 According to a third aspect of the present invention
32 there is provided a method of isolating a stretch of
33 pipeline extending between a first selected location
34 along said pipeline and a second selected location
35 along said pipeline, said first and second selected

1 locations being mutually separated along said pipeline,
2 said method comprising the steps of providing first and
3 second pipe-plugging pigs each according to the first
4 aspect of the present invention, transporting said
5 first pig along the bore of the pipeline to said first
6 selected location and there anchoring said first pig by
7 the method according to the second aspect of the
8 present invention, and transporting said second pig
9 along the bore of the pipeline to said second selected
10 location and there anchoring said second pig by the
11 method according to the second aspect of the present
12 invention.

13
14 Embodiments of the invention will now be described by
15 way of example with reference to the accompanying
16 drawings wherein:-

17
18 Figure 1 is a fragmentary longitudinal section of a pig
19 in accordance with the present invention with pig
20 anchors in a pre-anchored configuration;

21
22 Figure 2 is a view corresponding to Figure 1 but with
23 the anchors at an initial stage of anchor operation;

24
25 Figure 3 is a view corresponding to Figure 2 but with
26 the anchors at a subsequent stage of anchor operation.

27
28 Referring first to Fig. 1, part of a pig 10 is shown at
29 a selected location within the bore of a pipeline 12
30 (only one side of which is shown). The pig 10 has a
31 body 14 within which an anchor assembly 16 is mounted.

32
33 A circumferentially distributed array of slips 18 is
34 located around the periphery of the anchor assembly 16,
35 a suitable number of slips being eight for a pig having

1 a nominal outside diameter of 30 inches (762
2 millimetres). The slips 18 are allowed limited
3 movements in longitudinal and radial directions by slip
4 retainers which are omitted from the drawings for the
5 sake of clarity. The slips 18 are biased from the
6 positions shown in Figs. 2 and 3 to the position shown
7 in Fig. 1 by springs (not shown). The slips 18 have
8 radially inner faces 20 which are radially tapered, and
9 the periphery of the anchor assembly 16 is formed with
10 matching tapered faces 22. Consequently, when the
11 slips 18 are moved longitudinally to the left as viewed
12 in Fig. 1, with respect to the remainder of the pig 10,
13 by a hydraulic piston (not shown), the mutually
14 engaging tapered faces 20 and 22 interact to move the
15 slips radially outwards until their radially outer
16 faces 24 engage the bore of the pipeline 12, as shown
17 in Fig. 2 (to which reference will now be made). This
18 initial operation of the anchor system of the pig 10
19 can be powered by any suitable on-board hydraulic power
20 source, for example an accumulator (not shown) whose
21 output is controlled by a suitable control valve (not
22 shown) controlled in turn by any suitable control
23 circuit (not shown).

24
25 Fig. 2 shows the anchor system of the pig 10
26 immediately after its initial stage of operation but
27 before any subsequent stage of operation, ie the slips
28 18 have been moved to engage the bore of the pipeline
29 12 but the slips 18 have not yet been locked in their
30 bore-engaging positions. Such locking of the slips 18
31 is brought about by a locking mechanism now to be
32 described.

33
34 The locking mechanism comprises a plurality of plungers
35 26 each arranged to be radially slidable in a

1 respective radially extending bore 28 passing through a
2 respective one of the tapered faces 22 on the periphery
3 of the anchor assembly 16. In the non-locking
4 configuration of the locking mechanism as shown in Fig.
5 2, the radially outer end of each of the plungers 26 is
6 substantially flush with the respective tapered face 22
7 on the periphery of the anchor assembly 16.

8
9 Radial movement of the plungers 26 is caused by a
10 longitudinally movable piston 30 slidably sealed to
11 the bore of a cylinder 32 coaxially formed in the
12 centre of the anchor assembly 16 (itself coaxial with
13 the pig 10). Pipeline pressure at either end of the
14 pig 10 is conveyed to opposite faces of the piston 30
15 by respective hydraulic passages 34 and 36 such that
16 the difference in fluid pressures between opposite ends
17 of the pig 10 tends to move the piston 30 from the
18 high-pressure end of the pig 10 towards the
19 low-pressure end of the pig 10. The piston 30 is
20 biased leftwards as viewed in Fig. 2 by means of a
21 back-to-back pair of dished annular springs 38
22 (Belleville springs) acting between the rightward end
23 of the piston 30 (as viewed in Fig. 2) and the adjacent
24 end wall of the cylinder 32.

25
26 Rightward longitudinal movement of the piston 30
27 induced by a left-to-right differential pressure (ie
28 greater pressure in the passage 34 than in the passage
29 36) sufficient to overcome the leftward bias of the
30 springs 38 is conveyed to each of the plungers 26 by a
31 respective compression-resistant toggle strut 40 lodged
32 at its radially inner hemispherical end in a
33 circumferential concave groove 42 formed on the piston
34 30, and lodged at its radially outer hemispherical end
35 in a matching concavity in the radially inner end of

1 the respective plunger 26. This locking movement is
2 shown, at the moment of going over-centre, in Fig. 3
3 wherein the resultant radially outward movement of each
4 of the plungers 26 forces each respective slip 18 into
5 such tight engagement with the bore of the pipeline 12
6 as to ensure that the pig 10 can remain anchored
7 against very high differential pressures, which may
8 exceed 40 bar (ie the pig 10 is capable of self-
9 anchoring against full pipeline pressure on its left
10 end, with an empty vented pipeline at its right end).

11
12 Upon completion of the over-centering movement shown in
13 Fig. 3, the toggle mechanism constituted by the
14 plungers 26, the piston 30, and the struts 40 locks the
15 anchor slips 18 in tight engagement with the bore of
16 the pipeline 12 under minimal (or higher) differential
17 pressure across the pig 10 without any dependence upon
18 the on-board hydraulic supply utilised to produce the
19 initial stage of operation of the anchor system (ie the
20 transition from the Fig. 1 configuration to the Fig. 2
21 configuration). This ensures that anchorage of the pig
22 10 at the selected location in the pipeline 12 can
23 continue even if the on-board hydraulic supply should
24 fail, which is particularly important if the
25 pipeline-plugging pig 10 is being utilised for the
26 temporary isolation of a submarine oil pipeline
27 downstream of the location selected for the pig to be
28 anchored at, with the opening up of that downstream
29 part of the pipeline; failure of this pig anchoring
30 system would allow an uncontrolled release of the
31 pipeline contents into the sea.

32
33 The radially outer end faces of the plungers 26 may be
34 given high-friction surfaces to confer additional
35 security to the anchoring function, by preventing

1 slippage of the tapered slip surfaces 20 under
2 longitudinal loading. However, such high-friction
3 surfaces would be expected to prevent free relative
4 motion of the tapered surfaces 20 and 22 during
5 unlocking and release of the anchor slips 18 were it
6 not for the positive withdrawing action of the toggle
7 mechanism as the piston 30 moves leftwards (as viewed
8 in Figs. 1-3) to its inactive
9 differential-pressure-free position, under the biasing
10 influence of the springs 38.

11
12 Not shown in Figs. 1-3 are circumferentially extending
13 peripheral seals at each end of the pig 10, the seals
14 being a sliding fit on the bore of the pipeline 12 to
15 seal the pig 10 to the pipeline bore. The pig 10 thus
16 prevents any fluid flow between its opposite ends while
17 being free to be driven along the pipeline 12 by
18 differential fluid pressure between its opposite ends,
19 until such time as the pig 10 is halted at a selected
20 location along the pipeline and there anchored by the
21 anchor system and anchoring procedure described above.

22
23 The apparatus and method described above allow the
24 pipeline 12 to be temporarily blocked at a selected
25 location, and hence enable the pipeline 12 to be
26 isolated between that location and (for example) a stop
27 valve (not shown) or some other pipeline isolation
28 means. Greater operational flexibility may be achieved
29 by duplicating the pipe-plugging arrangement depicted
30 in Figs. 1-3, ie by providing a pair of pipe-plugging
31 pigs as described with reference to Fig. 1, inserting
32 and propelling both pigs down the pipeline, eventually
33 halting the pigs at suitable respective locations for
34 the isolation of a stretch of pipeline between these
35 locations, and there anchoring each of the pigs at

- 1 their respective selected location by use of the anchor
- 2 system and the anchoring procedures described above.
- 3

1
2 CLAIMS
3

4 1. A pipe plug comprising a pig adapted to be
5 transported along the bore of a pipeline and to be
6 controllably anchored at a selected location along said
7 pipeline, said pig comprising anchor means engageable
8 with the bore of the pipeline at said selected location
9 in an initial stage of anchor operation, and locking
10 means for locking the anchor means in engagement with
11 the bore of the pipeline at said selected location in a
12 subsequent stage of anchor operation.
13

14 2. A plug according to claim 1, in which the locking
15 means comprises over-centre toggle means disposed to
16 act upon said anchor means after said initial stage of
17 anchor operation to lock said anchor means in
18 engagement with the pipeline bore by over-centring
19 action whereby said anchor means are subsequently
20 retained in a locked condition in engagement with the
21 bore of the pipeline at least until a subsequent
22 reversal of said over-centring action of said toggle
23 means.
24

25 3. A plug according to claim 2, including means to
26 induce said over-centring action of said toggle means,
27 comprising pressure sensitive means responsive to a
28 difference in pressures at opposite ends of said pig.
29

30 4. A plug according to claim 3, in which said pressure
31 sensitive means comprises a piston means actuatable by
32 differential pressure across said piston means.
33

34 5. A plug according to any of claims 2 to 4, in which
35 said locking means incorporates spring means biasing

1 said over-centre toggle means away from a configuration
2 in which said over-centring action occurs.

3
4 6. A plug according to any preceding claim, in which
5 said anchor means comprises slip means and wedge means
6 movable relative to said slip means to urge said slip
7 means into engagement with the bore of said pipeline at
8 said selected location as said initial stage of anchor
9 operation.

10
11 7. A plug according to claim 6, in which said slip
12 means comprises a plurality of slips disposed around
13 the periphery of the pig and arranged to be movable
14 radially outwards of said pig by relative movement of
15 said wedge means in a longitudinal direction.

16
17 8. A plug according to claim 7, in which said wedge
18 means comprises a like plurality of wedges
19 longitudinally movable along respective paths radially
20 inwards of an associated slip and radially outwards of
21 said over-centre toggle means.

22
23 9. A plug according to claim 8, including means to
24 cause conjoint longitudinal movement of said wedges,
25 comprising hydraulic piston means.

26
27 10. A plug according to claim 9, in which the
28 hydraulic piston means comprises a hydraulic piston
29 longitudinally movable to act simultaneously on each
30 said wedge.

31
32 11. A plug according to any preceding claim, further
33 comprising seal means for sealing said pig to the bore
34 of said pipeline whereby substantially to prevent
35 interchange of fluid between portions of said pipeline

1 on either side of said pig.

2

3 12. A method of anchoring a pipe-plugging pig at a
4 selected location along a pipeline, said method
5 comprising the steps of providing a pipe-plugging pig
6 according to claim 1, transporting said pig along the
7 bore of the pipeline to said selected location, causing
8 the anchor means of said pig to undergo an initial
9 stage of anchor operation to engage the bore of the
10 pipeline at said selected location, and subsequently
11 mechanically locking said anchor means in engagement
12 with the bore of the pipeline at said selected
13 location.

14

15 13. A method of isolating a stretch of pipeline
16 extending between a first selected location along said
17 pipeline and a second selected location along said
18 pipeline, said first and second selected locations
19 being mutually separated along said pipeline, said
20 method comprising the steps of providing first and
21 second pipe-plugging pigs each according to claim 1,
22 transporting said first pig along the bore of the
23 pipeline to said first selected location and there
24 anchoring said first pig by the method according to
25 claim 12, and transporting said second pig along the
26 bore of the pipeline to said second selected location
27 and there anchoring said second pig by the method
28 according to claim 12.

29